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Lubrication

A Technical Publication Devoted to the Selection and Use of Lubricants

THIS ISSUE

Clay Products Machinery and Its Lubrication

PUBLISHED BY
THE TEXAS COMPANY
TEXACO PETROLEUM PRODUCTS

Texaco Lubricants for

THE CLAY PRODUCTS INDUSTRY

BRICK AND HOLLOW TILE MACHINERY

Skip Hoists

Wire Ropes	TEXACO CRATER COMPOUND NO. 0 OR NO. 1
Gears	TEXACO CRATER COMPOUND NO. 1 OR NO. 2
Hoisting Engine Bearings	TEXACO ALEPH OIL
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Bearings	
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Grease Lubricated	TEXACO CUP GREASE NO. 1 OR NO. 3
Gears	
Exposed	TEXACO CRATER COMPOUND NO. 1 OR NO. 2
Enclosed	TEXACO THUBAN COMPOUNDS OR TEXACO CRATER COMPOUND NO. 0 OR NO. 1
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Bearings	
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Table Lubrication	*(See Note)

Repress Machines

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Gears	TEXACO CRATER COMPOUND NO. 0 OR NO. 1
Cams	TEXACO ALEPH OIL OR TEXACO THUBAN COMPOUND H
Chains	TEXACO CRATER COMPOUND NO. 1
Press Lubrication	*(See Note)

*NOTE—Recommendations for table and press lubrication depend on the character of the clay, etc. Specific recommendations should be made only after suitable consideration of the conditions to which the oil will be subjected.

THE TEXAS COMPANY

Texaco Petroleum Products

135 East 42nd St., New York City

Atlanta, Boston, Butte, Chicago, Dallas, Denver, Houston, Los Angeles, Minneapolis, New Orleans, New York, Norfolk, Seattle

Recommendations for Pottery Machinery are shown on Inside Back Cover.

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Clay Products Machinery and its Lubrication

AMONG the industries which antedate the Christian Era and which played a distinct part in the development of civilization, the art of making bricks and working clay has had an influence upon our present day mode of living equalled only by the art of working metals. As an indication of the relative importance of the clay products industry, as it has come to be known, it ranks third among the coal consuming industries of the United States. It handles upward of 50,000,000 tons of clay per year. In the operation of its machinery approximately 5,000,000 gallons of lubricating oil are used yearly in the maintenance of the equipment required for handling raw material from the clay pits, preparing the product and working it into special shapes.

To accomplish the ultimate objective, the clay must be subjected to a wide variety of processes. In the handling of raw material, excavating machinery, pumps, and transportation equipment, either in the form of cars or hoisting machinery, are necessary. In the brick or tile plant the clay must then be tempered or mixed, foreign matter in the form of pebbles, roots, etc., must be removed by passing the product through suitable rolls; and where decorative tile is to be made, careful blending with certain products such as manganese, barium carbonate, or certain iron oxides, is essential, followed by screening, blending, or mixing which involve both dry and wet operations.

Final treatment before firing involves shaping which is carried out by the auger machine in the brick plant and the press in the manufacture of decorative tiling. Firing is a process essential to any type of clay product in order to render it resistant to change of form, breakage, or wear.

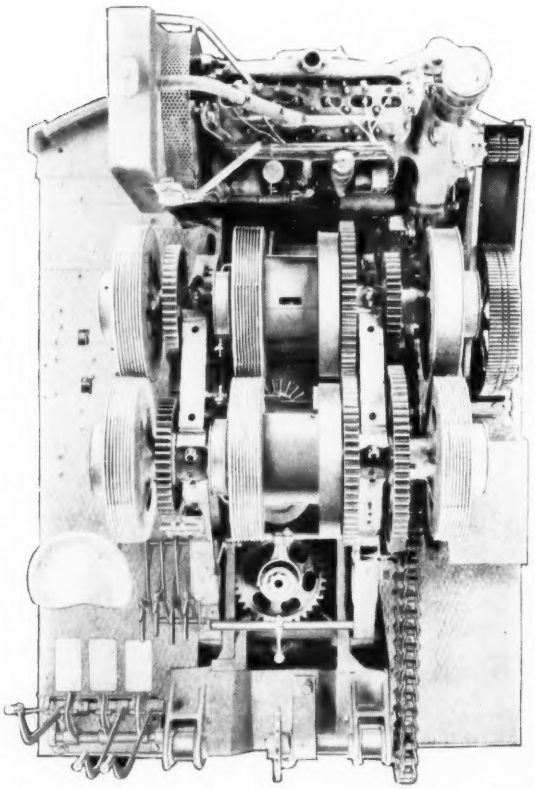
CLAY PIT EXCAVATING MACHINERY

In the handling of raw material from the clay bank, the power shovel and, in some cases, the dragline excavator are most extensively used. The power shovel works within a relatively limited area, handling its material by means of a shovel, dipper or grab bucket. The dragline excavator, on the other hand, is adapted to a wider area and operates by means of a boom and scraper bucket. This latter is dragged through the clay bank, being filled during the process.

In general design a power shovel consists of a revolving frame or turntable, which carries the boom or shovel arm, the engines and other operating mechanisms. A suitable carrying frame or truck which may be equipped with standard railroad wheels or mounted on a truck fitted with broad traction wheels of the trackless type, or a caterpillar tractor device may also be installed. In practically every case the machine is self-propelling.

Hoisting engines in use on the various types of power shovels may be either of the steam driven vertical or the horizontal type, receiving

their steam from a locomotive type or upright boiler located on the turntable. Gasoline, kerosene and electric power driven engines may be used if desired, to supplement the steam



Courtesy of Bucyrus-Erie Company

Fig. 1—Showing revolving frame and deck machinery elements on a gasoline driven shovel, adaptable to clay pit operations.

boiler and steam engines on certain types of shovels.

There are, in general, three engines required for the efficient operation of a power shovel, i.e., a hoisting engine which controls the rise and fall of the shovel or dipper, a swing engine for the revolving of the turntable, and a thrusting engine to operate the shovel in the process of digging.

Steam Cylinders

In order to keep power shovels in continuous operation, it is decidedly essential to give careful attention to their lubrication at all times. In machines which are steam driven, the existing conditions and methods of operation will be such that if any but a high grade, properly compounded lubricant is used, the cylinders will suffer accordingly.

Steam used on such machines will, in general, be of comparatively low pressure and may have quite an extensive moisture content. Although steam is taken from the highest part of the boiler, it will frequently be relatively wet when it enters the header. Furthermore, line condensation will be high between the boiler and engines, with a corresponding decrease in pressure, due to the fact that steam pipes are often not covered to any great extent, and the engines are frequently subject to intermittent operation.

As a result, there will almost always be an accumulation of water above the throttle valves, prior to starting the engines, depending in amount upon the length of time they have been stopped. If the cylinders are not covered with a tenacious film of properly compounded lubricant, the admission of these slugs of water will tend to wash the lubricant from the wearing surfaces, and for the next few strokes insufficient lubrication will be possible and scoring and abnormal wear may occur.

To counteract this, a grade of cylinder oil must be used which contains a sufficient amount of high grade animal or fixed oil to promote the formation of a tenacious film of emulsified lubricant, which will adequately resist the washing action of any water that may be present. The base of this lubricant should be a medium viscosity, highly adhesive, steam refined stock. For this purpose a comparatively high compound cylinder oil of about 130 seconds Saybolt viscosity at 210 degrees Fahr. has proved to be satisfactory.

In order to lubricate such steam cylinders efficiently the oil should be delivered by a positive feed lubricator, preferably of the force feed type, via suitable atomizers. The location of the oil pipes and atomizers in the steam lines is important. Where practicable these points should be from four to six feet back from the throttle valves. In cases where a steam thrusting engine is located on the boom in certain types of these machines, the oil line often enters the steam pipe much further back from the throttle, with the result that, in event of steam leaks at the ball or swing joint, there will be considerable loss of oil as well, with subsequent insufficient lubrication unless the leak is stopped.

Internal Combustion Engines

Where power shovels are driven by kerosine or gasoline engines instead of steam, lubrication develops into a problem similar to that involved in the tractor or automobile. For such service the motor lubricant is of chief importance and should be given careful consideration. Usually some form of force feed lubricating system is involved, which passes the oil through a hollow drilled crankshaft under sufficient pressure to reach all wearing parts. On gasoline engines a straight mineral oil of from 500 seconds to 750 seconds Saybolt vis-

cosity at 100 degrees Fahr. will be suitable, the grade being dependent upon the weather and operating temperatures. For tractor type engines a somewhat heavier lubricant should be used, the viscosity of which varies from 70 to 110 seconds Saybolt at 210 degrees Fahr.

Bearings

The general lubrication of bearings on the average excavating machine can be well taken care of by means of a medium viscosity straight mineral oil or a high grade compression cup grease. Many builders recommend grease lubrication and accordingly equip their machines with compression grease cups. Grease for this purpose should be free of acid or alkali, and should contain no filler such as talc or asbestos, which would tend to clog the oil grooves. External lubrication on excavating machinery, whatever its nature, is necessarily a difficult proposition, and enough dirt, dust and abrasive matter will work its way into the bearings, without the addition of any more in the form of improperly compounded greases.

Gears, Chains and Wire Rope

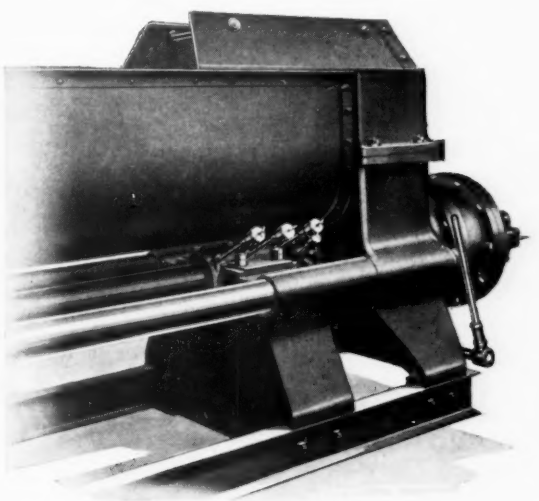
In order to insure the preservation of such equipment and maintain operation at the highest state of efficiency, it is essential to keep all gear chains and wire rope well coated with a suitable compound which will serve not only as a lubricant, but also as a preservative. Wire rope in particular requires attention, due to the possible hazard involved if internal strands are allowed to rust, wear and corrode. Although wire rope as constructed today contains a hempen core which is usually soaked in lubricant prior to the winding of the steel strands, the theory that this core will serve adequately to lubricate the strands and prevent wear, rust and corrosion during subsequent service should not be relied upon. Therefore, the exterior surface of the rope should be treated at frequent intervals with a suitable lubricant and preservative, which is capable of penetrating to the innermost strands during operation and not only relubricating the core but as well preventing wear at the points of contact of the strands.

Gears and chains should be treated with a similar compound. There is relatively no hazard involved if they are neglected, but wear will develop abnormally, accompanied by excessive noise and rattling. All teeth should so mesh that there will be a uniform and constant application of power and smooth, quiet operation in order to insure against jerky action. This latter would tend to produce strains and abnormal wear, not only on the gears, but also on other driving mechanisms. To attain best results in applying the gear lubricant, the surfaces of all teeth should first be washed with kerosene or some other solvent, the lubricant being then heated and brushed or poured lightly onto the wearing surfaces while the gears are in slow rotation. Pressure between the teeth will adequately spread the lubricant, if it is applied in the proper amount, and it should not be forced over the sides of the gears unless the film is too thick. In this event, the intensity of the application should be decreased.

BRICK AND HOLLOW TILE MANUFACTURE

Until the last century, bricks were made almost entirely by hand, their production being local to certain parts of the world and subsidiary to the more usual interests of agriculture and mining. Wherever there was a clay-bank perhaps the fortunate owner might intermittently mix up a batch of this product, press it by hand into crude moulds, dry the resultant bricks in the sun and finally fire them in a rough, wood-burning kiln. Usually his rate of production depended upon his own needs or the requirements of his immediate neighbors. Essentially it was a side-line, rarely a business, and yet it played a distinct part in the development of such localities.

Later, extended building construction necessitated a transition from this state of affairs, for production had to be increased. Crude

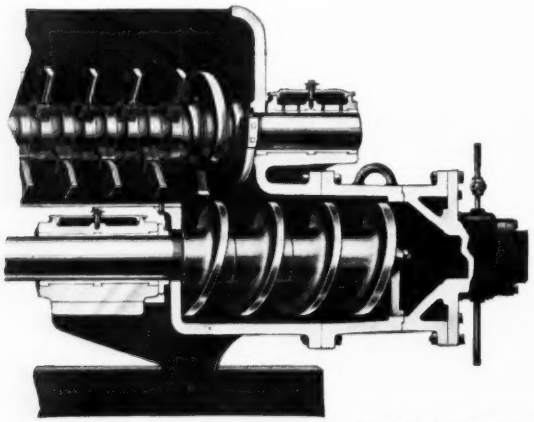


Courtesy of E. M. Freese and Company

Fig. 2—Front end bearing and grit collar of a combined auger machine and pug mill. The grit proof collar prevents entry of clay into the bearing. Note location of lubricators.

machinery was, therefore, developed. The tempering wheel was one of the earlier devices used for mixing the raw clay. The tempering wheel turns on an ever decreasing radius,

being drawn round and round in a large shallow circular box or hole in the ground into which raw clay is dumped. The purpose of such treatment is to increase the bonding



Courtesy of International Clay Machinery Company

Fig. 3—Details of an extruding pug mill, showing auger and knife mechanisms. Note construction of main bearings. The auger shaft is equipped with a Timken thrust bearing.

strength of the clay. Formerly a horse was hitched to a shaft projecting beyond the mixing pit, for the purpose of turning the wheel; today, however, wherever the tempering wheel is still in service, a small steam engine or electric motor is used. Decrease in radius of rotation whereby the wheel is continually turned through fresh clay, is attained by means of a rack and pinion mechanism.

Modern Clay Preparation Methods

While the tempering wheel proved to be a welcome improvement over earlier methods of mixing clay, it was incapable of delivering the output which twentieth century construction demanded. It has, therefore, been supplanted in the modern plant with such devices as the granulator, pug mill, disintegrator, dry and wet pans, and conical and straight rolls. Rolls are chiefly used where the raw clay is lumpy and contains stones, etc. Often a form of skip hoist, on the order of that employed in the charging of a blast furnace, is used where gravity plays a part in the subsequent handling of the clay. This hoist delivers the raw product to the granulator or conical rolls which automatically throw out any stones or other foreign matter. The clay then drops to a traveling belt or conveyor for transmission to the pug mill.

The granulator, as its name implies, serves essentially to break up lumpy clay; the pug mill being used chiefly for the thorough tempering of one or more grades of clay. Both machines, however, involve a steel trough in which a horizontal shaft carrying a screw or series of blades is rotated by means of a train of gears and an electric motor or belt connection from a line shaft. Where the granulator involves the first step in the breaking up of the clay, it may not do this thoroughly, in which event a set of straight rolls or a disintegrator equipped with rolls of different diameter must be installed as a subsequent piece of equipment, in order to complete the process.

Function of the Auger Machine

The final stage in the mixing of the clay is attained through the auger machine. The essential function of this device, however, is to pass the clay through a suitable mould or die in the form of a continuous bar, which may subsequently be cut into the requisite standard lengths of finished brick or hollow tile, according to the shape of the die. As its name implies, the auger machine consists of an auger-shaped shaft which is rotated in a suitable compartment by means of a train of heavily built gears. Usually an auger machine is designed for the use of an extensive number of dies of various sizes and partitions in order to facilitate not only the production of solid bricks but also of the several forms of hollow tile in general use today for construction purposes.

As the clay bar is compressed and forced through the die, it passes onto a traveling belt which delivers it to the cutting machine. Cutting is usually carried out by means of a wire. In the manufacture of brick this may be designed either for end or side cutting; hollow tile, and other forms of building tile, however, must always be end-cut.

Kiln Treatment

After cutting, the plastic sections are stacked by hand onto drier cars for drying and hardening. Front or face brick, enamel brick and firebrick or other high temperature refractory shapes are, however, subjected to additional pressing before drying. This is done on a special pressing machine which not only insures a firm consolidation of the clay, but also squares up the edges and corners. Repress machines may be hand operated, or motor or belt driven, the bricks, etc., being fed to them either automatically or by hand, according to the facilities of the plant.

Drier cars, as the primary means of transportation in the plant, occupy an especially prominent position in the manufacture of brick and building tile, etc., the number used in the average plant generally running into the hundreds. A drier car is a relatively simple piece of apparatus, consisting chiefly of an iron frame-work mounted on wheels which run on narrow gage tracks.

Wheel bearings require very careful consideration from a lubrication viewpoint, due to the comparatively high temperatures under which the lubricant must function when the car is in the kiln. For this reason anti-friction bearings as a refinement in construction have been given considerable study.

These cars serve to carry the various products to the drying rooms or tunnels and later to the kilns. When the drier cars are properly stacked they are rolled on industrial tracks to a heated dry room, where the contents are brought to practically complete dryness. The purpose of this is to insure against cracking or warping of the clay products when they are ultimately subjected to the higher temperature of the kilns.

LUBRICATION OF BRICK AND HOLLOW TILE MACHINERY

In the average brick and hollow tile plant the machinery is massive and rugged, operating in the presence of considerable moisture, dust and abrasive clay. Furthermore, many of the parts are subject to abnormal pressures, rendering lubrication a matter of considerable importance if the potential wear-producing effects are to be counteracted.

Clay Handling Equipment

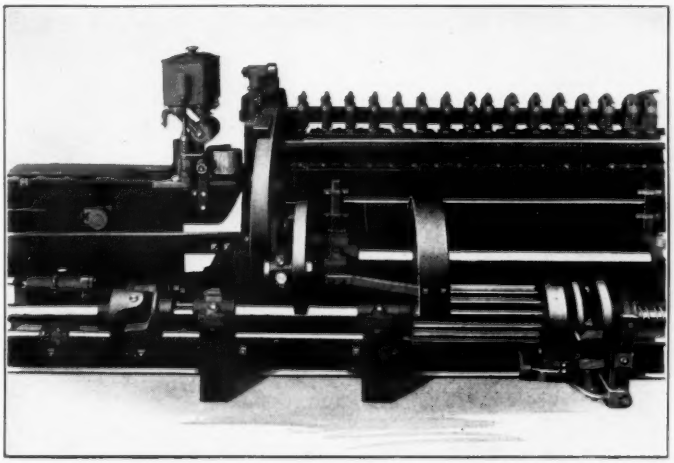
Preliminary handling of clay in many brick and hollow tile plants is carried out by a hoist and skip car. Through a wire rope connection to a hoisting engine at the top of the skip-track, carloads of clay are periodically hoisted and automatically dumped to the granulator. Due to the fact that this rope oftentimes runs slack, taking up with a pronounced jerk at frequent intervals, its lubrication is always important; the more so as wear will tend to become abnormal. Every effort should be made, therefore, to see that wire rope is effectively lubricated with a suitable grade of semi-solid straight mineral wire rope compound, capable of not only penetrating to the core of the rope, but also lubricating and preserving the strands to a maximum. Such a lubricant is most effective when applied hot by means of a split box, through which the rope can be drawn, thereby insuring that the entire surface of the latter comes in contact with the lubricant.

This same grade of lubricant can also be used on the gears which drive the drum of the hoisting engine. Here it should likewise be applied hot, preferably to the gear teeth as they roll into mesh. It is important to remember that an excess of such a lubricant will impose a decided drag upon the machine and materially increase its power requirements.

Bearings and steam cylinders of the hoisting engines should be lubricated with the same type of products used in the engine room. In general, a straight mineral oil of from 200 to 300 seconds Saybolt at 100 degrees Fahr., will be suitable for practically all external bearings in the brick and tile plant, regardless of whether they are ring oiled, pressure lubricated, or served by oil cups or an oil can. Skip car wheel journal bearings in turn can be lubricated with the same product, or perhaps even black oil. Where roller bearings are installed on these cars, however, a pressure resisting grease capable of remaining within the bearing should be given consideration.

Rolls and Disintegrators

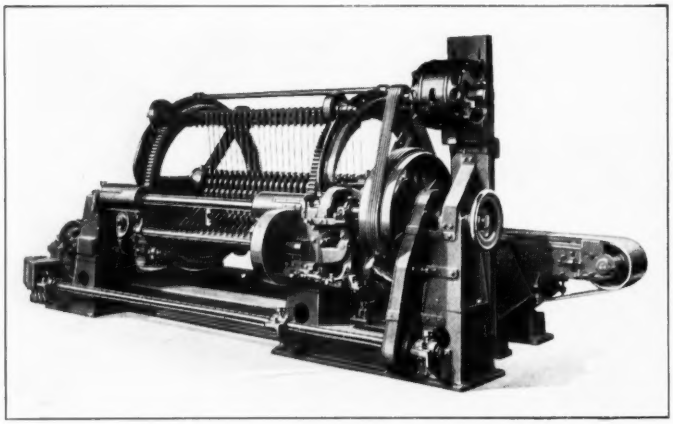
Roll machinery, including conical, as well as straight rolls and disintegrators involve bearings, and reduction gears where they are motor driven. Unless clearances are abnormally great on such bearings, even though they may be subjected to rather high pressures, the grades of engine oil specified above will be suitable. It is rarely good practice to attempt to use heavier oil in order to compensate for high clearance inasmuch as the increase in fluid friction which will result may increase power consumption to a certain extent, until the temperature of operation rises sufficiently to reduce the oil viscosity, whereupon the expected benefits from the use of heavier oil will disappear. It is better to renew bearings, if necessary, in such cases, for operating and power savings will certainly pay for the trouble.



Courtesy of E. M. Freese and Company

Fig. 4—Showing oiling arrangement, branding roller and air cushion on a reciprocating automatic clay cutter.

Where such bearings are provided for grease lubrication, a medium bodied compression cup grease will serve the purpose, and can be used in either compression cups or with pressure lubrication fittings.



Courtesy of The Bonnot Company

Fig. 5—Showing a rotary brick cutter with motor drive. To improve accuracy in operation and reduce power consumption, this machine is equipped with roller bearings and machine cut gears.

Gear lubrication in turn can be effected with the same lubricants as used on the hoist, being careful of application to avoid throwing.

Clay Treating Machinery

Granulators, pug mills and auger machines which comprise the various equipment for clay treating prior to cutting are discussed together inasmuch as their general operating features from a lubrication viewpoint are quite similar. In brief, these will involve main shaft bearings, reduction gears of spur and bevel type and the thrust bearings in the auger machine. As a rule, gears operate exposed as elsewhere in the plant, except on certain types of auger machines. Where exposed their lubrication requires the use of a sufficiently viscous lubricant to insure its retention by the teeth regardless of the action of pressure or the penetration of abrasive foreign matter which would tend to "ball-up" the lubricant and often cause it to drop or be thrown off by centrifugal force. A straight mineral gear compound of from 1000 to 2000 seconds Saybolt at 210 degrees Fahr., will be adaptable for this service. Enclosed gears, however, can be run in a bath of lubricant if the gear case is sufficiently tight; in this event, a more fluid product of about 200 seconds Saybolt at 210 degrees Fahr., may frequently serve the purpose.

Bearing construction in such machines will vary according to the intricacy of design. As a rule, provision is made for automatic lubrication either by means of ring or chain oilers, waste pad attachments, sight feed oil cups, multiple oilers or compression grease cups. Force feed lubrication has even been tried out on some brick machines with considerable success. The multiple or manifold oiler and the force feed lubricator will normally assure of more positive lubrication and prevent entry of foreign matter, although they may cost more to install than individual lubricators. Whatever the system of lubrication, where oil is required, a straight mineral engine oil of from 200 to 300 seconds Saybolt at 100 degrees Fahr., will be suitable. Grease cups in turn will require a good grade of medium bodied compression cup grease.

Auger Machine Thrust Bearings

The most important factor as to lubrication is the thrust bearing in the auger machine. The compressing and forcing of the clay bar through the forming die exert a considerable back thrust upon the rear end of the auger shaft. This is usually taken up either by a self-aligning, adjustable end thrust, a marine collar type of thrust bearing, or a roller thrust bearing which either runs in a bath of oil, or is served by a force feed lubrication system with a constant stream of oil by means of an oil pump operated by the machine. The selection of the proper grade of oil is usually the problem at hand. For a bath oiled thrust bearing, a straight mineral oil of from 300 to 500 seconds Saybolt Viscosity at 100 degrees Fahr., will be suitable. For a pressure system, however, a lighter product will often be best, having a viscosity of from 200 to 300 seconds according to the size of the machine.

Die Lubrication

To insure constant feed against the continual pressure exerted by the clay in its passage through the auger machine die, to relieve the machine of abnormal back pressure or thrust, and aid in the formation of a smooth surfaced clay bar, the die must also frequently be suitably lubricated. Oil, water, or steam can be used for this purpose, depending upon the construction of the die and the nature of the clay. Where oil is used, a low viscosity straight mineral product is recommended by many authorities. Others prefer to compound with a certain amount of fatty (animal) oil. These same products can also be used as table oils for the lubrication of the surface of the cutting machine over which the clay bar must slide. Unless this table is properly lubricated, the bar may buckle, necessitating considerable loss

of time and perhaps damage to the machinery. Table oils are often reduced to a certain extent with kerosene according to the nature of the oil, the type of clay and manner of operating the machine.

Clay Cutting Machines

The usual moving parts in clay cutting machines should normally cause but little concern from a lubrication viewpoint. Gears, bearings, and cam elements are involved. In consequence, the grades of lubricants specified above for such elements can be readily used with satisfaction. Here, as on the auger machine, automatic oiling equipment is installed wherever practicable to insure positive lubrication with maximum protection of wearing parts.

On such machinery coordination of motion between the conveying apparatus and the cutter itself is of extreme importance. Cutting reel speed, in other words, must synchronize with the movement of the clay bar. Effective lubrication is one of the chief mediums by which this can be brought about in a properly designed machine.

Die and Table Oils

It is important to remember, however, that friction between clay and metal must be considered, just as in the auger die. As the clay bar slides over the table of the machine it must not bind, else coordinated operation will be materially interfered with. To insure against this the table is oiled. Products which will develop a minimum of scum or discoloration of the finished clay materials should be used. In many plants, the lubricant is referred to as a table oil, in others, it is known as a press oil, for it must also be used in lubricating the dies and guides of repress brick machines. For this work, both straight mineral oils and fixed oil compounds will be suitable, reduced with kerosene as necessary.

Where the product slides over the lubricated surface such as on the cutting machine, straight mineral oils are claimed by many to function equally as well as compounded oils. Where pressing is involved, however, the latter must be used since mineral oils alone may give rise to adhesion of the clay and imperfect delivery of the bricks. The ratio of reduction may vary from 1 to 2, to 1 to 20, according to the work at hand.

Repress Operations

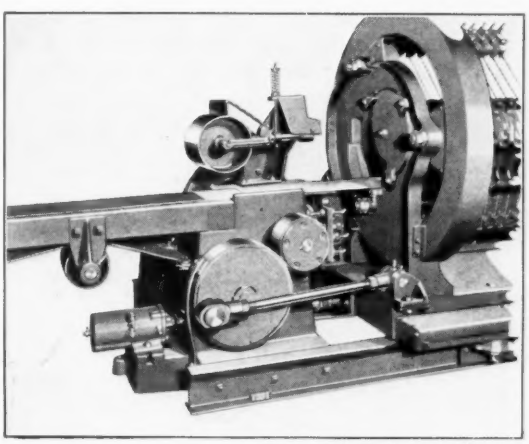
In the repressing of special forms of brick the machinery differs materially from any other equipment already discussed. On the other hand, the essential wearing parts which require lubrication are quite similar. As a result, the several grades of gear and bearing lubricants already referred to can be used as necessary. Press form lubrication is very much the same as table lubrication which has just been discussed above, though it has been found that straight mineral oils cannot be used. Oil is usually fed to the press forms from a storage chamber built into the machine itself.

The only feature of difference affecting the operation of wearing parts is the amount of pressure involved. In some cases this might render it advisable to lubricate bearings and cams with a somewhat heavier grade of lubricant of perhaps 500 seconds Saybolt viscosity at 100 degrees Fahr.

Drier Cars

In the lubrication of drier car wheel journals, a problem due to heat must be considered. These latter are usually equipped with roller bearings. Essentially the problem involved is to select a lubricant of such characteristics that it will resist the liquefying and carbonizing effects of heat. This becomes most aggravating when the cars pass through continuous tunnel kilns because under the best conditions a certain amount of abnormal heat will reach the wheel bearings even though sand seals and insulated car construction may be employed.

In certain operations, practice has indicated that a semi-solid, high temperature grease is adaptable for the lubrication of these bearings. Ordinarily it should be a product containing a mineral constituent of relatively high viscosity, high flash point and low carbon residue content.

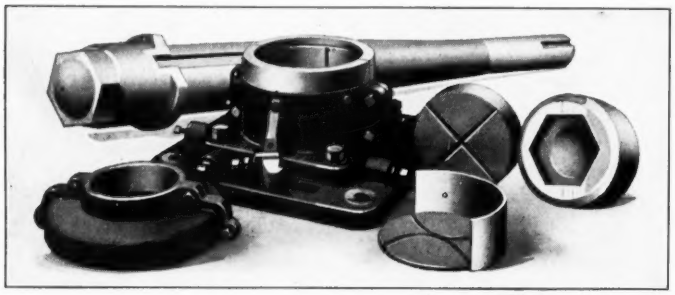


Courtesy of E. M. Freese and Company

Fig. 6—Friction power-return and air cushion on a rotating automatic cutter. The cutting reel is equipped with Timken roller bearings.

By virtue of these characteristics, unless temperatures are distinctly abnormal, the lubricant should remain within the bearing in plastic condition for a considerable length of time. Use of such a product where test may

prove it practicable should normally indicate greater economy than where an oil is employed, although first cost might be somewhat higher. The specific savings would show up in the labor item, due to reduction in the frequency of lubrication.



Courtesy of The Bonnot Company

Fig. 7—Details of a step bearing of a grinding pan. This device includes an oil tight casing and cover arrangement to exclude dust. The step is lubricated through oil piping which extends outside the pan.

Where drier car bearings are not given the proper attention from the viewpoint of lubrication they may frequently give trouble. The necessity for daily or trip lubrication, with subsequent neglect on the part of careless employees will generally be the reason for this. Such a lubrication procedure, however, will only be necessary where comparatively light oils are used.

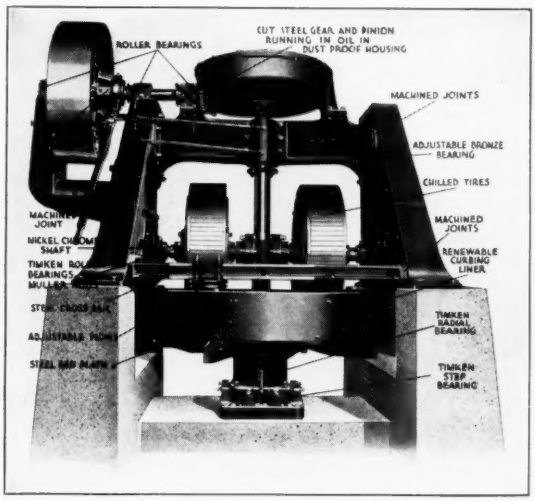
THE MANUFACTURE OF POTTERY

In the manufacture of pottery, architectural tile, terra cotta, and sanitary porcelain, etc., the preparation of the clay is of far more importance than in brick plants. A considerably higher grade of clay is used for such products than for the making of bricks and building tile. Clay of this nature is usually free from any extensive amount of foreign matter. It is received in the plant in individual storage bins, one for each grade of clay which is used in preparing the desired mixture. Distribution of these products to their respective bins is carried out by overhead screw conveyors, driven by belts or electric motors through silent chain connections. As the clay is dumped into the receiving end of each bin, the screw conveyor distributes it uniformly out to the discharge end by simply channelling the top of the pile. The mechanical equipment used in the storage department is naturally subjected to considerable dust, even though the products may be relatively dry. As a result, the lubricants used must be of such a character as adequately to protect the wearing surfaces and resist admixture with abrasive dust.

Grinding Processes

In many cases the raw clays must be ground before mixing especially where they are lumpy or mined in coarse state, as are certain glaze constituents. Usually a crusher of the reciprocating or gyratory type is used for preliminary pulverization, which is generally done at the mines. The former is preferred for the coarser materials. The resultant product is then oftentimes passed by gravity, bucket or belt conveyor to the grinding pans. These are termed wet or dry, according to the moisture content of the clay and whether or not water is added during the grinding process.

A grinding pan is simply a large round shallow pan of 5 to 9 feet in diameter in which two or more grinding wheels are located, so that their peripheral surfaces are set close to the bottom of the pan. Treatment in this machine will reduce the product to a relatively fine state of pulverization. The wet pan is used for tempering or increasing the bonding strength of the clay; the dry pan serves to pulverize the raw product so that it can be screened to uniform size and homogeneity. Pans of this nature are also used extensively in the heavy clay product plants where refractory materials and sewer pipe are manufactured. Final grinding of glaze ingredients is done in a ball mill.



Courtesy of The Bonnot Company

Fig. 8—Showing constructional details of a heavy pan or clay grinder. Note extent to which roller bearings have been adapted and that the gear and pinion run in a dust proof, oil tight housing.

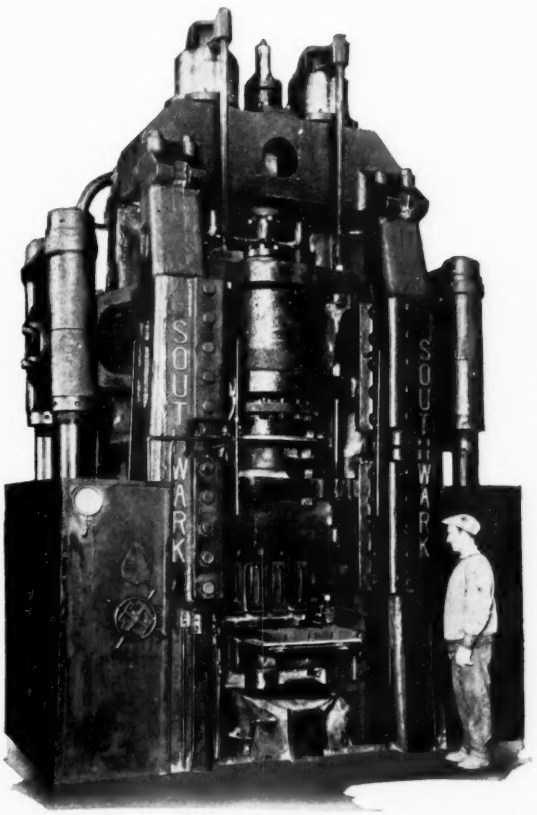
Mixing

From the grinding process the clay is passed either to a pug mill, or directly to the blungers. The pug mill is essentially a mixing machine, wherein tempering is also accomplished. Pug

mill treatment may not always be necessary, serving as it does merely to effect a rough initial mixing of plastic ingredients. In the manufacture of sanitary porcelain, pottery and architectural tile the blunger does the real mixing.

Blunger Operation

This machine involves a vat in which suitable paddles revolve, which are actuated by an electric motor or belt connection through suitable gearing. The clay is fed into the vat in company with sufficient water to effect a fluidity of approximately that of cream. After sufficient agitation in the blunger the mixture is pumped or run by gravity over a set of lawns or agitating sieves which receive their reciprocating motion through a motor-driven eccentric connection. In some cases these sieves will simply remove coarse siliceous particles, but where the raw product is fed directly to the blungers from the bins, there may still be considerable foreign matter present in the nature of roots, stones, gravel, etc. All this must, of course, be completely removed.

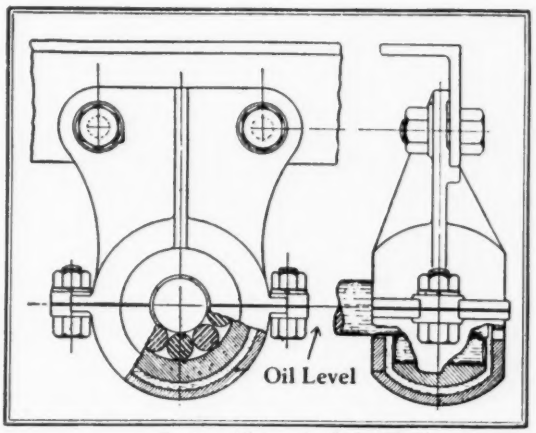


Courtesy of Baldwin-Southwark Corporation

Fig. 9—Showing an 800 ton brick press. By virtue of the size of this machine, lubrication must be given careful consideration.

Pressing Machinery

Screening accomplishes the desired results after which the product is in a suitable state for pressing out the excess water and reducing to the plastic consistency of workable clay. This is done by pumping it through a series of filter presses under a pressure of approximately 110 lbs. per sq. in. In fluid condition the clay is termed "Slip." The pumps are known as slip pumps.



Courtesy of International Clay Machinery Company

Fig. 10—Structural details of a dryer car wheel roller bearing, showing recommended oil level.

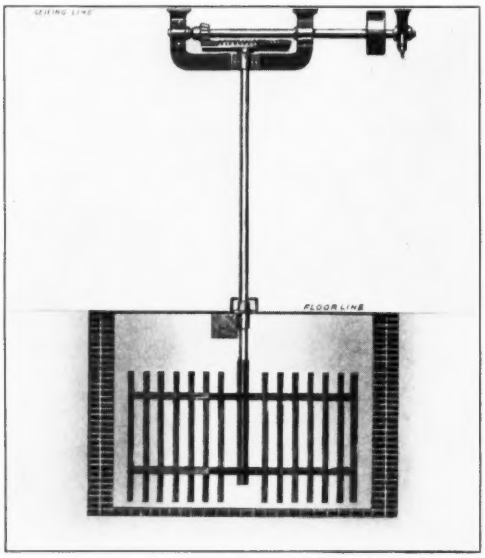
The outside packed vertical type of motor or belt driven plunger pump has proved adaptable to such service, having from two to four cylinders. The lubrication of pump plungers is one of the several problems in the industry due to the extremely abrasive nature of the flints and spars in the slip. Effective lubrication is highly essential in the interest of protecting the packing.

Purpose of Ageing

From the filter presses the cakes of clay pass to the storage cellar or ageing room. It is sometimes necessary to store certain clays over an extended period; frequently as much as two months' time is desirable. The purpose of such storage is to enable the clay to age, in the course of which process certain organic chemical reactions take place which improve the body and reduce the subsequent tendency to crack during moulding, casting or firing.

During the period of storage in the ageing room the clay is kept constantly covered with wet blankets or sacks, in order to prevent evaporation. After sufficient ageing the clay is fed through a pug mill or auger machine in order to consolidate the material into a firm compact bar, by removing all air spaces. This bar is cut by hand into suitable lengths as it is forced through the die of the machine, the

sections being then ready for moulding or "batting" into finished shapes. This completes the mechanical treatment to which clay is subjected in many potteries and terra cotta plants.



Courtesy of The Crossley Machine Company, Inc.

Fig. 11—Details of a ceiling type clay agitator, used for handling liquid clay or slip before pumping to the filter press.

Moulding Machinery

Hand moulding in the manufacture of vitreous china and porcelain such as bath-tubs and other sanitary products, however, has been done away with in many localities. In such plants the aged clay is led back through a series of blungers to render it sufficiently fluid for passage over the sieves. Oftentimes certain chemicals such as sodium carbonate or silicate are added to defloculate the slip during the reblunge treatment. The resultant product is then pumped by slip pumps through a distributing pipe line to the casting room. Here moulds of plaster of paris are set up as in terra cotta work, the only difference being that the clay flows into them instead of being "batted" in by hand. Casting naturally saves cons derable time and labor, though it is usually only adaptable to plants wherein standardized production is maintained.

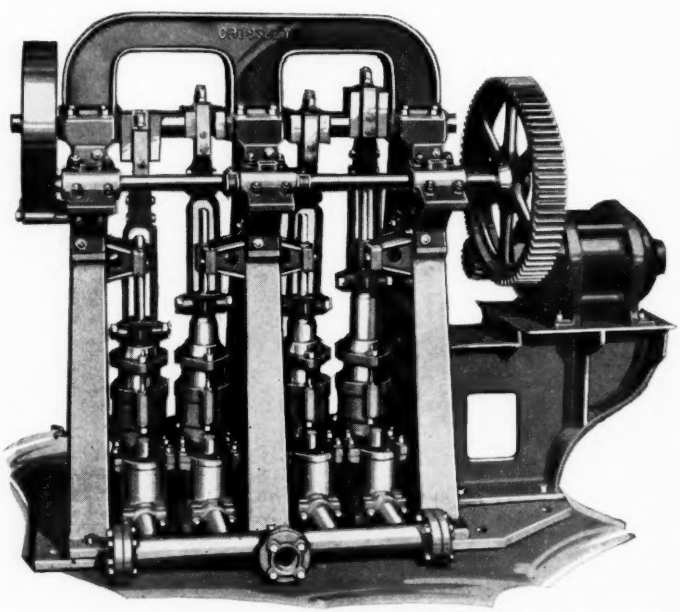
A similar process is employed in the manufacture of architectural tile such as is used for floor and wall surfacing, etc., with the exception that the clay usually receives but one blunging. The clay cakes as they are taken from the filter press go to a drying room for a short period of storage. It is desirable to have the clay retain from 10 to 12 per cent of water, however. In some potteries it is dampened before pressing. Complicated shapes such as moulding require about 1 to 2 per cent more water. Tile making is essentially a matter of subjecting the clay to high pressure in dies of various shapes, using presses of either the motor driven or hand operated type.

LUBRICATION OF POTTERY MACHINERY

All the machinery discussed in connection with the manufacture of tile, porcelain, and terra cotta, requires careful lubrication if production is to be maintained at a minimum cost of operation. Some equipment, however, because of its construction or the conditions under which it functions, will be subject to more than usually severe service. This will apply particularly to the thrust bearings of auger machines, the plungers of the slip pumps, and the step bearings of wet and dry pans. Auger machine lubrication has already been discussed under the lubrication of brick-making machinery. Slip pumps and grinding pans being more peculiar to the manufacture of tile, porcelain and similar finer wares, are given particular consideration below:

Slip Pump Plungers

The essential problem in slip pump lubrication pertains to the plungers. Slip pumps can be either driven by an individual electric motor or by belt connection from a common



Courtesy of The Crossley Machine Company, Inc.

Fig. 12—A 4 cylinder slip pump. Plunger lubrication must be given careful study in the operation of this machine, to protect plunger packing against cutting action of clay.

line shaft above. The usual moving parts will comprise an assembly of gears and bearings which can normally be effectively lubricated with the products recommended elsewhere in this article for such elements. Plungers, however, must be given more careful study due to the abrasive nature of the slip and its cutting effect upon the plunger packing. Here it is necessary to use a lubricant of sufficient viscosity to protect this latter as much as possible. Usually a steam cylinder stock or black oil of medium viscosity will be satisfactory, although certain potters report a high degree of success using lard oil.

Grinding Pans

For the final grinding of many clays, wet and dry pans are used. In this operation, the problem of lubrication of step bearings is involved. These latter are usually either of the convex plate or roller type. Considerable weight is borne by such bearings; also the possibility of entry of dust or other abrasive material is prevalent. Therefore, they must be kept well supplied with a good grade of 300 to 500 viscosity engine oil which will furnish an adequate lubricating film and insure the exclusion of all foreign matter. Normally, such bearings should be protected as much as possible with a suitable dust-tight cover.

Other wearing parts, such as gears and bearings will seldom give trouble if supplied with proper lubricants, suited to the operating conditions, at such a rate as to preclude dripping or splashing.

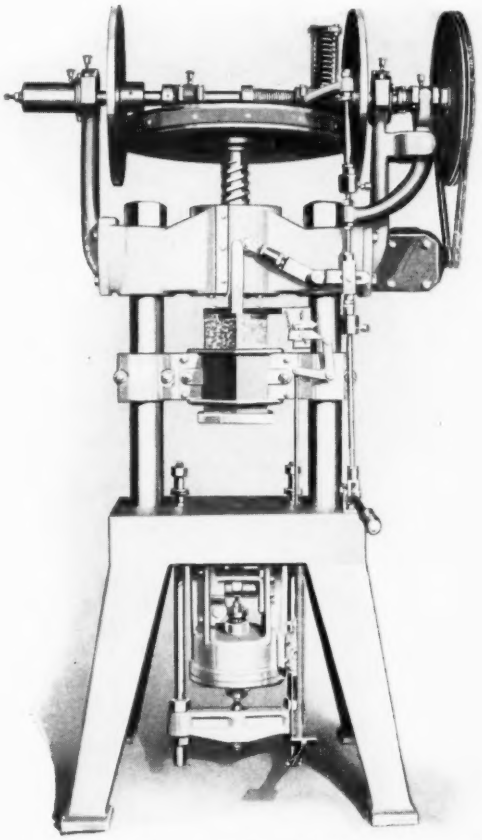
Press Lubrication

The manner in which tile press dies are lubricated will have a marked influence on production. The purpose of lubricating the dies or mixing oil with the raw material is to prevent adhesion of the clay and to insure delivery of the product in the proper shape with perfectly straight edges and square surfaces.

Mineral oils in compound with fixed oils have proved to be very satisfactory lubricants for this service, the purpose of the fixed or fatty oil being to counteract, by emulsification, the effect of the moisture in the clay and to give a perfectly lubricated surface to the die. It is customary to prepare press oils of this nature of varying concentration and viscosity by reducing the purchased product with a certain amount of kerosene. The nature of the clay and the work at hand is usually the guiding factor in the determination of the type of press oil necessary and the proportion of kerosene to be added.

Miscellaneous Equipment

Elsewhere in the pottery, the gears, bearings, guides and perhaps cams which are involved on clay distributing equipment, ball mills, blungers, screens, line shafting, pug mills, sagger presses, auger machines, conveyors, and drier cars, can be adequately lubricated by the various oils or greases already mentioned in connection with brick-making machinery.



Courtesy of The Crossley Machine Company, Inc.

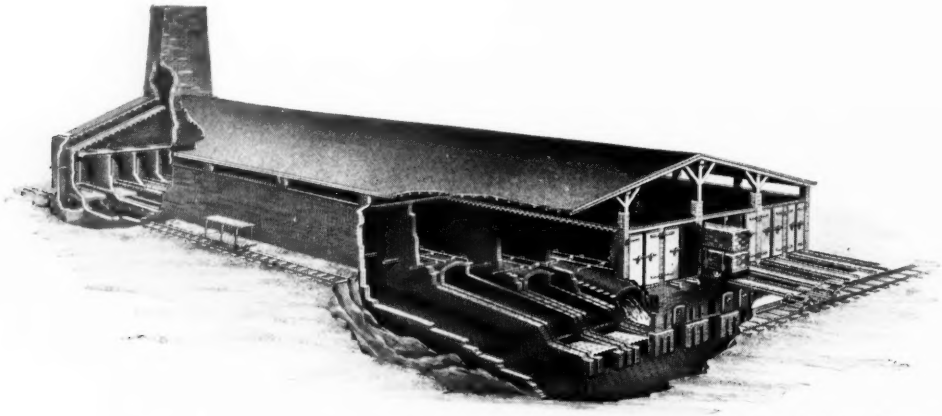
Fig. 13—Front view of an air ejecting tile press. Ball bearings mounted in dust proof housings, as well as a ball bearing thrust are used on this machine, to reduce power consumption and facilitate operation.

DRYING AND FIRING

Following the processes of pressing, cutting, moulding or casting, the clay shapes must be dried until nearly bone dry, the length of time depending on the nature and size of the pieces. This involves treatment in waste heat or direct fired dryers at a temperature in the neighborhood of 200—250 degrees Fahr. After this they are fired to bring about complete contraction and hardening of the clay and render the finished products resistant to wear or discoloration.

The nature of the firing process will depend upon the type of material being handled. Common brick, building tile, electric porcelain, and terra cotta tile are single fired, the latter

products being frequently glazed and fired in the green state, the glaze and body maturing at the same time. Wall and floor tile, chinaware, and sanitary porcelain, on the other hand, are double fired, first in the "biscuit" at high temperature, and then at a lower temperature after glazing.



Courtesy of International Clay Machinery Company

Fig. 14—Phantom view of a dryer, showing relative location of car tracks and provision for circulation of heat.

Firing of clay products is one of the most important stages in their manufacture. Essentially the object is the same whether common brick or the most artistic of terra cotta is involved, viz., to burn the product to a permanent state of hardness. Depending upon the product, more or less care must be exercised in this process, not only in control of temperatures, but also in the time of treatment.

Where products such as enamelled brick, tile, and porcelain ware are concerned the possible discoloring effect of the gases of combustion upon the glazed surfaces must always be considered. Modern practice is to observe every effort to insure oxidizing conditions in the kiln. To this end some plants use kilns of the muffled type, the clay products being charged into the muffled heating chamber around which the gases of combustion circulate.

Larger pieces of porcelain ware, such as kitchen sinks, bath tubs, etc., can also be fired in a compartment type of gas fired kiln which does not require a muffle for the production of a very satisfactory glazed surface. Vitreous china such as tableware, small sanitary pieces, and architectural tile are either fired in muffled kilns, or clay containers known as saggers, in direct contact with the heat.

In charging the kiln the saggers are either set one on top of the other where the smaller varieties of ware are to be fired or else the top sagger is inverted to enclose the protruding portion of the piece above the sides of the bottom sagger. In order to prevent the direct contact of the gases of combustion with the ware, the rim of each sagger is sealed to that of its neighbor by means of clay wads.

During the process of firing, the heat is regulated by observation of pyrometric test cones (termed Seger cones) inserted in the kiln. These are composed of various siliceous and mineral substances which give them varying melting points. Electric pyrometers are also used in some potteries. In addition test samples of the same composition as the ware being fired, and frequently small rings of clay which change color at different temperatures are placed in the kiln, so as to be capable of withdrawal for observation of color and condition of glaze at normal room temperatures.

Kiln Car Bearings

In view of the comparatively high temperatures involved in pottery kiln operations, practical experience has indicated that a comparatively light viscosity straight mineral oil will give best results in lubricating the kiln car bearings. As a general rule, these latter are of roller type construction and practice in the majority of potteries is to oil each bearing before the cars begin a trip through the kilns. In many cases, kiln temperatures may range as high as 600 degrees Fahr. This is no indication that this will be the temperature of the car wheel bearings in view of the fact that water cooling coils are, in many cases, placed in the base of the kiln, on a level with the bearings. Cars are oftentimes constructed with an insulated overhang so as to prevent direct circulation of heat to the space below the car body.

In the selection of oils for such service, preference in many potteries is to use a product which will develop as little carbon residue as possible within the bearings, should this oil be vaporized by the prevailing heat.

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